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17007-EEF

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April 2017

Abstract
We test different strategies for borrowers who may choose, within a 20-day time slot, the moment to arrange a loan. The strategy that is most successful in minimizing the interest rate does not use historical data, but starts by observing interest rates for a number of days, and then chooses the day with an interest rate that compares favorably. However, differences in outcomes of the strategies are too small to matter much. Organizational or behavioral motives to choose a particular borrowing strategy should be decisive.

Keywords: optimal stopping problem, interest rate, secretary problem, treasury management

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Choosing the optimal moment to arrange a loan

Introduction

In cases where credit is needed, this is usually known well in advance. Examples include existing loans coming to maturity that need to be refinanced and funds needed for investment projects: in no well-managed organization any of this will come as a surprise. This provides borrowers the option to choose the moment when a loan is arranged. Instead of waiting until the funds are needed, a loan can often be arranged earlier, using a so-called forward start. This means that there is a time lag between the contract date, i.e., the moment when the loan is arranged and the interest rate is set, and the date the funds are made available.

To illustrate that forward starts are quite common, we present some statistics from a dataset of loans of BNG Bank to Dutch municipalities and intermunicipal organizations in 1997-2015.[2] Because of the exceptionally high creditworthiness of Dutch municipalities, one phone call or email suffices to secure a loan that starts the same day.[3] However, we find that 65 percent of these loans have a forward start. Although half of these have a forward start of less than 10 days, the maximum is a staggering 2,193 days (about 6 years). The average forward start, counting the zeroes, is 71 days; the median is 2.

Forward starts may be used for different reasons. First, a forward start may appeal to risk-averse borrowers. By arranging the loan as soon as the need for capital has become clear, a cost increase as a result of rising interest rates is prevented. A second reason is that loans may have to be approved at meetings of high-level officials that take place with intervals; e.g., as part of a budget for a project. If, e.g., money is needed in six weeks' time and meetings where a loan can be approved are held monthly, a forward start of several weeks is to be expected. Finally, and most relevant for this paper, a forward start may be chosen by a borrower who expects the interest rate to rise. By arranging the loan now, at the current rate, the loan will be cheaper - provided the borrower was right.

Figure 1 shows the relative decrease in the benchmark interest rates between contract date and the date where the loan starts in the BNG Bank dataset. Loans represented by dots above the zero line have become more expensive as a result of the forward start, because the interest rate went down after signing the contract. Loans represented by dots below the zero line have become cheaper. In fact, gains and losses seem to cancel out on average since the trend line in the Figure (not shown) almost coincides with the zero-line. On average, loans have become 0.1 percent (not percent point) cheaper as a result of forward starts. There is a wide variation, however. The effect of a forward start ranges from 50 percent cheaper to 43 percent more expensive, as shown in Figure 1.

[2] The dataset contains bullet loans with maturities of 5 and 10 years, annuity loans with maturities of 10, 15, 20 and 25 years, and linear loans with maturities of 5, 10, 15, 20 and 25 years.

[3] All loans in our dataset are risk-free. Dutch municipalities do not default, as a result of an explicit bailout clause enshrined in the law (Allers, 2015). The Dutch state, which bails out municipalities if necessary, could default in theory, but has very high credit ratings. The loans to intermunicipal organizations included in the dataset are risk-free because municipalities guarantee them.

Figure 1. Relative benchmark interest rate decrease between contract and start of loan (percent)

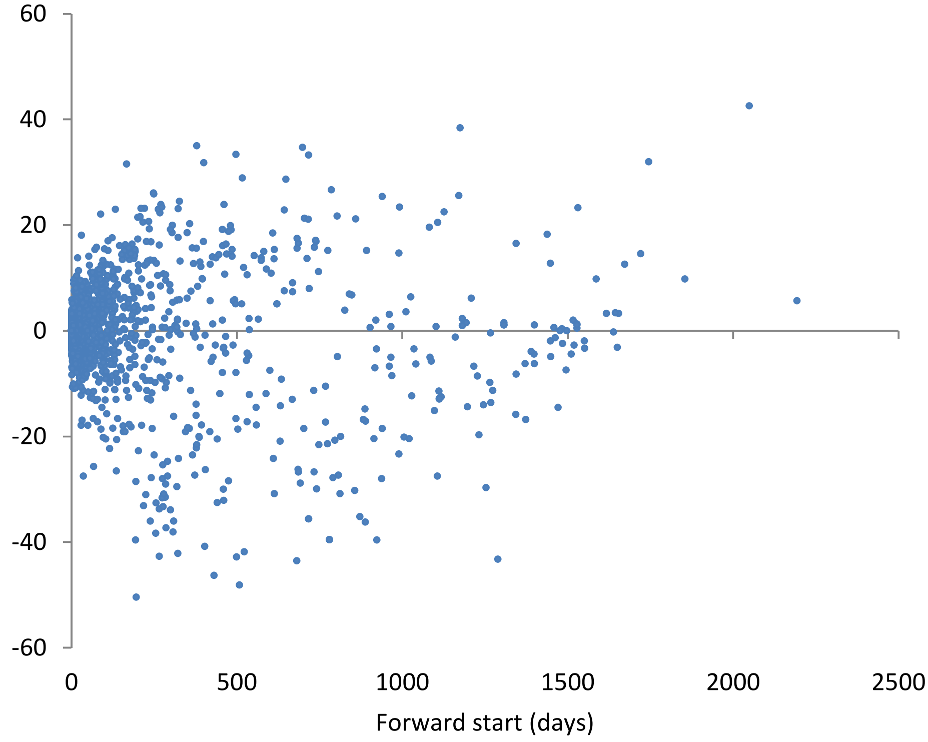


Figure 1 does not point to clear cost savings as a result of forward starts, but, as we have seen, that may not always have been the objective. This raises the question whether successful timing strategies exist that borrowers may use in order to secure relatively cheap loans. Perhaps knowledge of previous interest rates may help select the best date to fix the interest rate.

Efficient markets theory does not predict that short-term interest rates follow a random walk (Mishkin, 1978; Pesando, 1979). However, it has been suggested that in the absence of time-varying term premiums, long-term interest rates approximately follow a martingale series when observed over a short period (Sargent, 1976; Pesando, 1979, 1980). In that case, the best prediction of tomorrow's interest rate is today's interest rate, even when all previous interest rates are known. This is supported by a number of studies that present advanced methods to predict bond rates, but often fail to beat the random walk model (Fauvel, Paquete, and Zimmermann, 1999; Baghestani, 2009). Of course, efficient markets theory relies on assumptions, which may not be met in practice. Indeed, there exists an entire industry producing financial predictions that have no value if markets are fully efficient.

For certain model assumptions and well-defined goals, an effective strategy to find a low interest rate in a pre-determined time interval may exist. For example, in times of high volatility, it may pay to wait for a day with an interest rate that is lower than those in the previous days. Thus, information about previous interest rates could help select the best moment to arrange a loan.

We can formulate this as a so-called optimal stopping problem, where an irreversible choice must be made under uncertainty and within a finite time horizon (see Peskir and Shiryaev, 2006 or Allaart et al, 2012 and the references therein). A well-known example is the secretary problem (e.g., Ferguson, 1989), where the best secretary must be selected from n applicants. The applicants are assessed successively, and after each assessment the candidate is either chosen or dismissed. A dismissed applicant cannot be called back. The interviewers are able to rank all assessed applicants, but have no information at all about candidates who have not (yet) been assessed. The optimal decision rule (or, to be more precise, an approximation that becomes closer as n increases) is to dismiss the first n/e candidates, which we call a 'test set'.[4] We then select the first applicant who is better than the best candidate in the test set. In case a better candidate does not turn up, the last candidate is chosen.

Our case differs from the secretary problem because data about historical interest rates is available. This means that is it not necessary to sacrifice options in order to generate a test set. In this paper, we consider a number of simple strategies that can be applied without expert knowledge or high cost. We test whether each of these strategies would have been successful in the previous two decades. Obviously, this does not necessarily mean that strong conclusions can be drawn from this about the success of these strategies in the future.

Problem definition

In order to conduct empirical tests, the problem must be defined clearly. Assume that a loan has to be arranged regularly. Each time, on day d = 1 it becomes known that, on day d = 20 at the last, a certain amount of credit must be available. The interest rate varies from day to day (and not during the day, we assume). Data about interest rates on previous days is available. The challenge is to find a strategy that selects, within the decision period of 20 days, the day with the best interest rate. With days we mean office days; days on which a loan can be arranged.

It is not obvious how the performance of a strategy should be measured. We consider four possible targets to measure the success of a particular strategy. The first objective is: maximize the probability that the strategy selects the lowest interest rate of all interest rates within the decision period. This parallels the objective in the secretary problem. An important drawback of this objective is that, in most cases, the lowest interest rate will not be selected, in which case we do not optimize the interest rate that is chosen. Our second objective does not have this limitation: it aims at choosing the lowest expected value for the chosen interest rate. That is, it aims to select the lowest interest rate *on average* when the choosing procedure is repeated many times.

The drawback of that objective is that interest rates in different periods cannot always be meaningfully compared, because the market rate can change significantly over time. The third objective circumvents this, by aiming to minimize the expected value of the ratio of the selected interest rate and the lowest interest rate within the decision period.

For risk-averse borrowers, however, this will probably still be unsatisfactory. That is because a strategy may be successful on average, but have greatly varying outcomes. In that case, it may work out rather disappointingly in a particular case. The fourth objective therefore aims to minimize the variation in the selected interest rate (as measured by the standard deviation of the outcomes when the strategy is applied at different moments). This objective may be used in combination with either objective 1, objective 2, or objective 3.

[4] Here, e is the base of the natural logarithm, approximately 2.72.

Strategies

We study five classes of strategies. Strategy 1(k) is to look back passively during a reference period of k days, k = 1..20. The lowest interest rate from that period is taken as the reference rate. Strategy 1(8), e.g., is to wait for a day when the interest rate is lower than or equal to the lowest rate in the 8 days preceding d = 1, and then arrange the loan. Strategy 1a is to wait until the interest rate is *strictly* lower than the reference rate. If no lower interest rate comes before the last available day, the loan is arranged on d = 20.

Strategy 2(k) is to look back actively for k days, k = 1..20. On each day within the decision period, which runs from d= 1 to d = 20, one looks back to the k days preceding that day. The lowest interest rate from that reference period is the reference rate. The difference with strategy 1 is that the set of k reference days is shifted one day towards the future on every day within the decision period, while this set is fixed in strategy 1. Strategy 2 is to arrange the loan as soon as the interest rate is equal to or lower than the reference rate. Strategy 2a is to wait until the interest rate is strictly lower than the reference rate. Again, if no (strictly) lower interest rate materializes, the loan is arranged on day 20.

Strategy 3(k) is to first determine the drift (difference in interest rate) between k days before d = 1 and d = 1, for k = 1..20. If the drift is positive, the loan is arranged immediately (d = 1). If the drift is negative, one waits for d = 20 to arrange the loan. Thus, this strategy compares interest rates on two days only.

Strategy 4(k) follows the classic secretary approach. No historical data are used. Instead, k days are used to observe interest rates, k = 1..20. The lowest rate within this period is the reference rate. The loan is arranged as soon as the interest rate is equal to or lower than (or strictly lower than, strategy 4a) the reference rate, or, if such an interest rate does not appear between day k+1 and day 20, at the last day.

Strategy 5(d) is the simplest: always choose a fixed day d to arrange the loan. E.g., always select d = 1, d = 7 or d = 20.

More formally, we define strategies according to the following stopping moments:

$$\tau_1^k = \min\{d = 1 \ldots 20 \mid r_d \leq \min_{1\leq j\leq k} r_{1-j}\} \qquad \tau_{1a}^k = \min\{d = 1..20 \mid r_d < \min_{1\leq j\leq k} r_{1-j}\}$$
$$\tau_2^k = \min\{d = 1 \ldots 20 \mid r_d \leq \min_{1\leq j\leq k} r_{d-j}\} \qquad \tau_{2a}^k = \min\{d = 1..20 \mid r_d < \min_{1\leq j\leq k} r_{d-j}\}$$
$$\tau_3^k = 1_{r_1 \geq r_{1-k}} + 20\ 1_{r_1 < r_{1-k}} \qquad \tau_{3a}^k = 1_{r_1 > r_{1-k}} + 20\ 1_{r_1 \leq r_{1-k}}$$
$$\tau_4^k = \min\{d = k+1 \ldots 20 \mid r_d \leq \min_{1\leq j\leq k} r_j\} \qquad \tau_{4a}^k = \min\{d = k+1 \ldots 20 \mid r_d < \min_{1\leq j\leq k} r_j\}$$
$$\tau_5^k = k$$

where r denotes interest rate. If no stopping time is found, day 20 is selected.

Empirical research

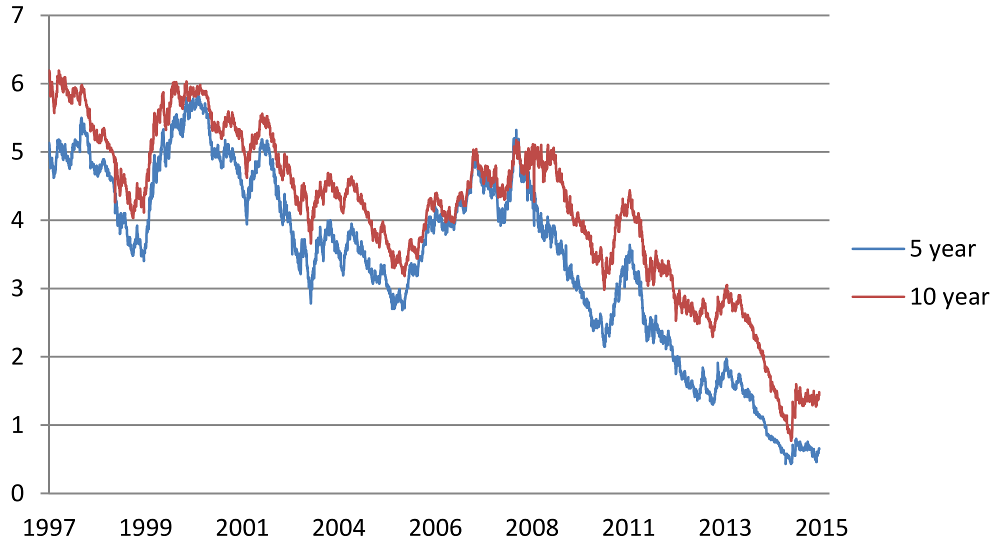
We test these strategies using historical benchmark interest rates from BNG Bank, with different maturities and different amortization schemes, from January 2, 1997 up to December 31, 2015. BNG Bank is the Dutch market leader in credit for (quasi) public organizations like municipalities, IOs, water authorities and housing corporations. Benchmark interest rates are used by the bank in negotiations with clients requesting a loan (for detailed information, see Allers and Van Ommeren, 2016). Benchmark rates are based on Euribor for short term loans and on swap rates for long term loans, and contain surcharges for profit, cost and liquidity. The benchmark rate, which depends on the amortization pattern and on maturity, is derived before the start of every business day by feeding the current market interest rates into an automated system.

Interest rates on loans with a forward start are usually higher than on loans without a forward start. Pricing is based on immediate borrowing by the bank, on the capital market, until maturity, and lending to a third party for the period until the loan starts. Lending the money to a third party in the period between contract date and the day the loan starts usually yields a low interest rate; lower than the rate the bank itself has to pay. The resulting loss in the first period has to be compensated by a premium on the interest rate during the second period, leading to a higher interest rate. The forward start surcharge depends on the maturity, the length of the forward period and the term structure of the loan. For forward starts up to 20 day, this surcharge is low; approximately one basis point (0.01 percent point).[5] In the empirical analysis we therefore do not take this into account. In our discussion of the results we will come back to the forward start surcharge.

We apply every strategy on each of the 238 consecutive series of 20 office days that existed within our data period. The strategies are tested for bullet loans with maturities of both 5 and 10 years, and for linear loans with maturities of 10, 15, 20 and 25 years, because for such loans, benchmark interest rates are available. Bullet loans are loans where the principal is paid back at maturity. Linear loans are loan where the principal is paid back in equal installments. For both loan types, interest on outstanding debt is paid annually. Figure 2 shows interest rates for bullet loans with 5 and with 10 year maturity in our data period. Interest rates on other loan types followed a similar pattern.

[5] Cost neutrality for the bank implies: $(1 + Rn)^n = (1 + Rd)^d * (1 + Rf)^{n-d}$. Here, Rf is the forward interest rate of a loan starting at year d and ending at year n; Rn denotes the current interest rate for loans with a maturity of n years; Rd the current interest rate for loans with a maturity of d years. Solving this equation for Rf yields $Rf = \left(\frac{(1+Rn)^n}{(1+Rd)^d}\right)^{\frac{1}{n-d}} - 1$. Substituting the average benchmark interest rates for Rd (20 days) and Rn (both 5 and 25 years) in our data period yields a forward start surcharge of 1.6 and 0.5 basis points, respectively. Of course, banks are free to deviate from this theoretical surcharge, e.g., by adding a profit margin, or by not bothering to apply a surcharge for short-term forward starts at all.

Figure 2. Benchmark interest rates for 5 year and 10 year bullet loans, 1997 – 2015.

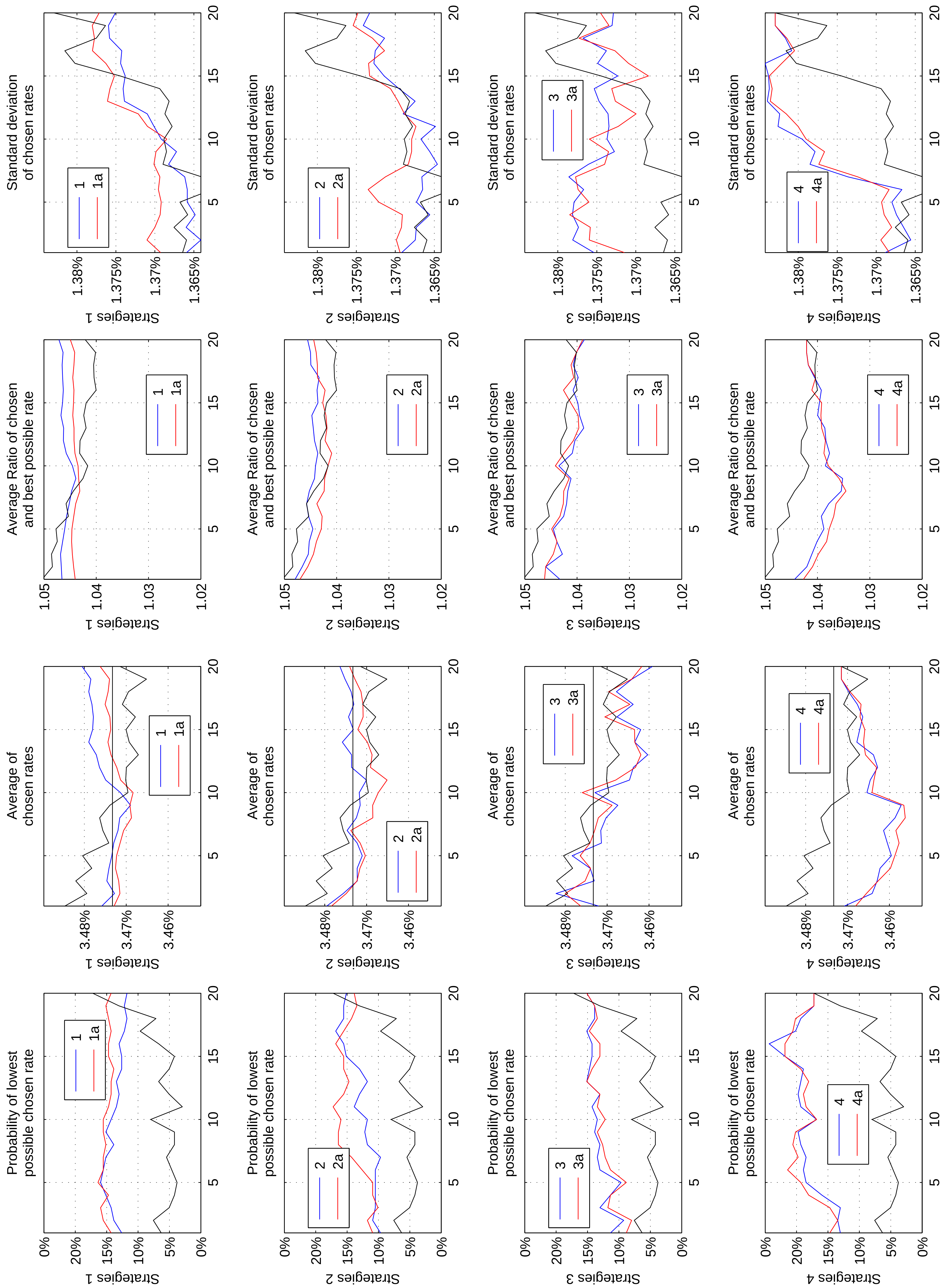


We plot the outcomes in graphs which are organized in four rows and four columns. Each row corresponds to a strategy; however, strategy 5 is shown in every row (black* lines). Each column corresponds to one of the four objectives described above. Figure 3 presents the results for bullet loans with 5 year maturity. The other loan types we studied yield similar results, which may be found in the Appendix.

The first column of Figure 3 shows, for each strategy, in what percentage of cases the lowest interest rate from all interest rates within the decision period is selected. On the horizontal axis is k, the length of the reference period. For strategy 5, which does not have a reference period, d is on the horizontal axis. A value of 15 for a k of 8 denotes, e.g., that this strategy, using a reference period of 8 days, selects the lowest interest rate 15 percent of the time. In this column, higher means better.

Column 2 presents, for each strategy, the average value of the selected interest rates. The horizontal black lines in this column show the average benchmark interest rate in the research period. Column 3 presents the ratio between the selected interest rate and the lowest of all interest rates within the decision period. Column 4 shows the standard deviation of the selected interest rate (in percent point) over all 238 periods of 20 working days within our research period. In columns 2, 3 and 4, lower means better.

Figure 3. Simulation results for bullet loans with 5 year maturity



Results

Table 1 summarizes the results for bullet loans with a maturity of 5 years. For objective 1, which maximizes the probability that the lowest interest rate from all interest rates within the decision period is selected, strategy 4, the secretary approach, is optimal, with k = 16. Note that this value of k is higher than the theoretical optimum of n/e, which approximately equals 7. Recall that this theoretical optimum is an approximation, which is better for high values of n. Also, interest rates may not necessarily appear in random order, which is one of the assumptions for the theoretical result which establishes optimality of this approximation. Using strategy 4(16), in 24 percent of all cases, the lowest available interest rate was selected (Table 1). The second-best strategy is 5(20): always arrange the loan at the last possible moment. This yields the best interest rate in 17 percent of all cases. This strategy is relatively successful because the interest rate went down more often than it went up in the research period under consideration (1997-2015). The difference between outcomes of the best performing strategy and the second-best is 7 percent point, whereas the difference between the best and the worst performing strategy, 5(11), is 21 percent point.

Table 1. Best, second-best and worst performing strategy per objective; 5 year bullet loans

Objective	Best strategy	Result (%)	Second-best strategy	Result (%)	Worst strategy	Result (%)
1 Most often lowest rate	4(16)	24.4	5(20)	17.2	5(11)	2.9
2 Lowest rate on average	4a(8)	3.456	3(20)	3.459	5(1)	3.485
3 Lowest $^{\text{selected rate}}/_{\text{best actual rate}}$	4a(8)	103.5	3(20)	103.9	5(1)	105.0
4 Lowest standard deviation	5(6)	1.363	1(2)	1.364	4(16)	1.384

For objective 2, selecting the lowest rate on average, the secretary approach performs best as well; this time, waiting until the interest rate is strictly lower than the reference rate (strategy 4a) is slightly better than waiting until it is equal to or lower than the reference rate (strategy 4). The optimal k equals 8, which is close to the theoretical optimum of the secretary problem; recall, however, that this theoretical optimum is based on objective 1. Strictly speaking, with objective 2, strategy 4 is second best (as shown in Figure 3), but because 4 and 4a are close variations on a theme, we include 3(20) as second best in Table 1. This strategy implies arranging the loan immediately in case of a positive drift, and waiting as long as possible in case of a negative drift, with the maximum reference period of k = 20. The difference in outcomes between best and second best is only 0.3 basis points (0.003 percent point). The outcome of the worst performing strategy, 5(1), differs 2,9 basis points from that of the best performing strategy.

As explained, objective 3 may be the most relevant for many organizations. This objective minimizes the ratio of the selected interest rate and the lowest available interest rate in the decision period. Again, the secretary approach dominates, with k = 8. On average, the selected interest rate was 3.5 percent (not percent point) above the lowest available rate. As with objective 2, strategy 4a is slightly better than strategy 4, and the second best strategy is 3(20). With strategy 3(20), the selected interest rate was 3.9 percent above the lowest available rate.

The good performance of the secretary approach is remarkable. In many cases, it performs better than looking back passively (strategy 1), even though it sacrifices k days of the decision period to collect data, and even though is does not aim to optimize objective 3 but objective 1. Compared with strategies 2, 3 and 5, strategy 4 also performs well for many values of k (until k = 10..15, depending on loan type; see Figure 3 and the Figures in the appendix). Strategy 4 often performs best with objective 1 or 2, too.

Based on objective 4, which minimizes the standard deviation of the selected interest rate, strategy 5(6) would be preferred, followed by 1(2) as a second best. Strategy 4 performs tolerably well with this objective, as long as k is below 7. For k = 13-16, on the other hand, strategy 4 has the highest standard deviation of all strategies (Figure 3).

The most important lesson to be drawn from column 4 in Figure 3, however, is that outcomes vary greatly over time. The standard deviation exceeds 100 basis points for every strategy. Differences in standard variations between strategies are relatively limited. Compared to their standard deviations, differences in outcomes of strategies are very small.

As already mentioned, a forward start results in a higher interest rate to compensate the bank for making the funds available before they are needed. For forward starts up to about 20 days, this surcharge is in the order of one basis point. This surcharge should be subtracted from the gains of using a strategy with a forward start, but, as we have seen, this cost is negligible compared to the variation in the outcomes over time.

Conclusion

In cases where a borrower may choose, within a limited time slot, the moment to arrange a loan, and thus the moment the interest rate is determined, it is probable not advisable to spend much time on this choice. Based on a comparison of five classes of simple strategies, applied to interest rates from 1997-2015, we conclude that differences between the outcomes of the strategies are small, and that the variation in outcomes of each strategy over time is much bigger. One of the strategies we studied, the classic secretary approach, performs better than other strategies in many cases, but the potential gains from using this strategy are dwarfed by the variation of outcomes over time. Our empirical analysis is based on benchmark interest rates from one bank, BNG Bank of the Netherlands, but these are closely related to international market rates, so we presume our results may be generalized to other settings in the same period.

Because differences in outcomes are found to be small, organizational or behavioral motives to choose a particular borrowing strategy may be decisive. In cases where, e.g., a certain budget has been allocated to a project, it may be sensible to immediately arrange a loan carrying an interest that fits within the budget, if such a loan is available at that moment. This ensures that rising interest rates cannot jeopardize the project. More generally, risk-averse borrowers could decide to use a maximum forward start, i.e., arrange the loan immediately, while risk-neutral persons could decide not to use a forward start, thus avoiding a forward start surcharge on the interest rate.

However, borrowers who want to use the strategy which just outperformed the other strategies we considered in recent history should go for the secretary approach. This easy to apply strategy promises good results for different maturities and different optimizing criteria, while no historical data are needed.

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Appendix: simulation results

Figure A1. Simulation results for bullet loans with 10 year maturity

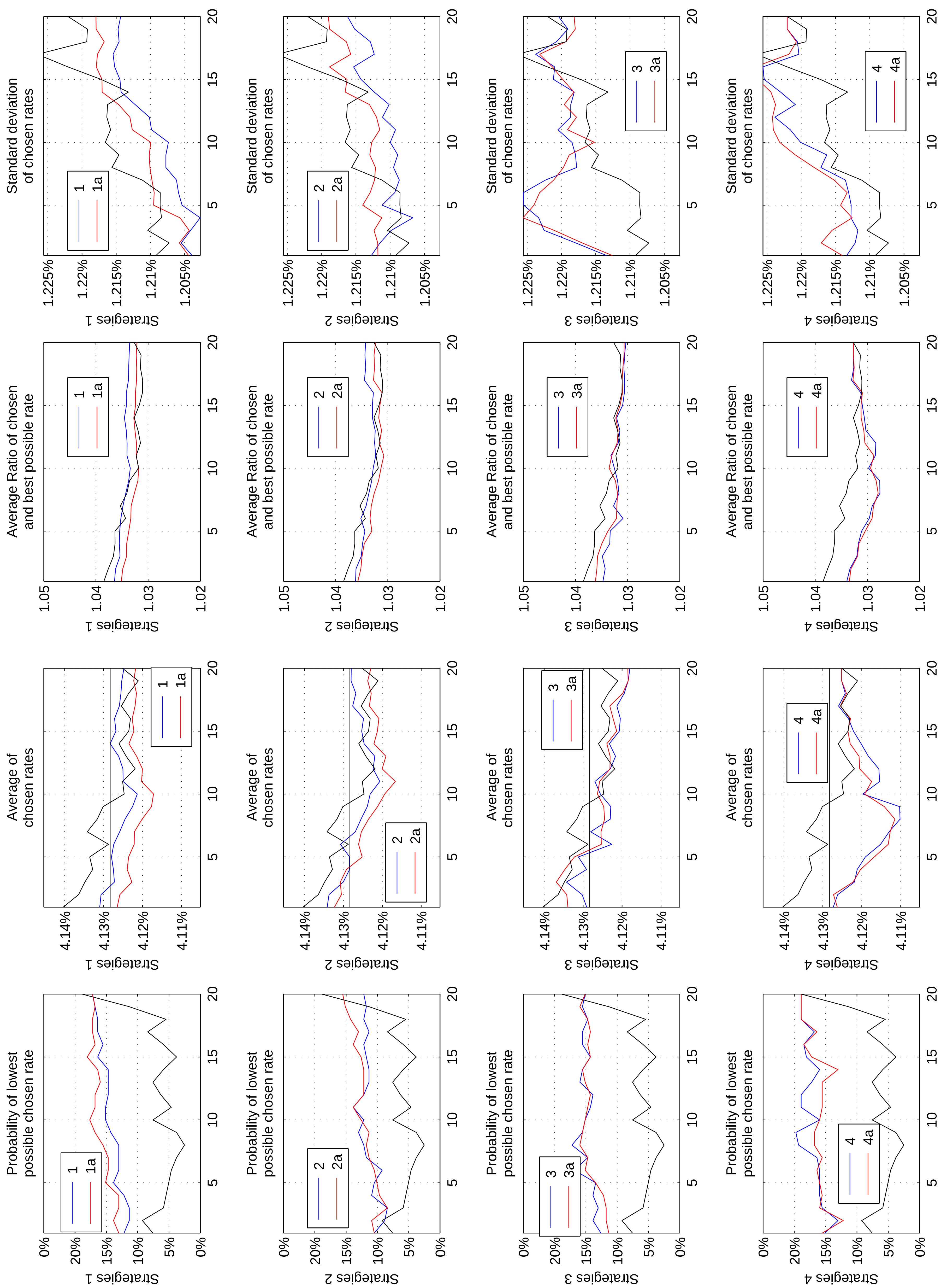


Figure A2. Simulation results for linear loans with 10 year maturity

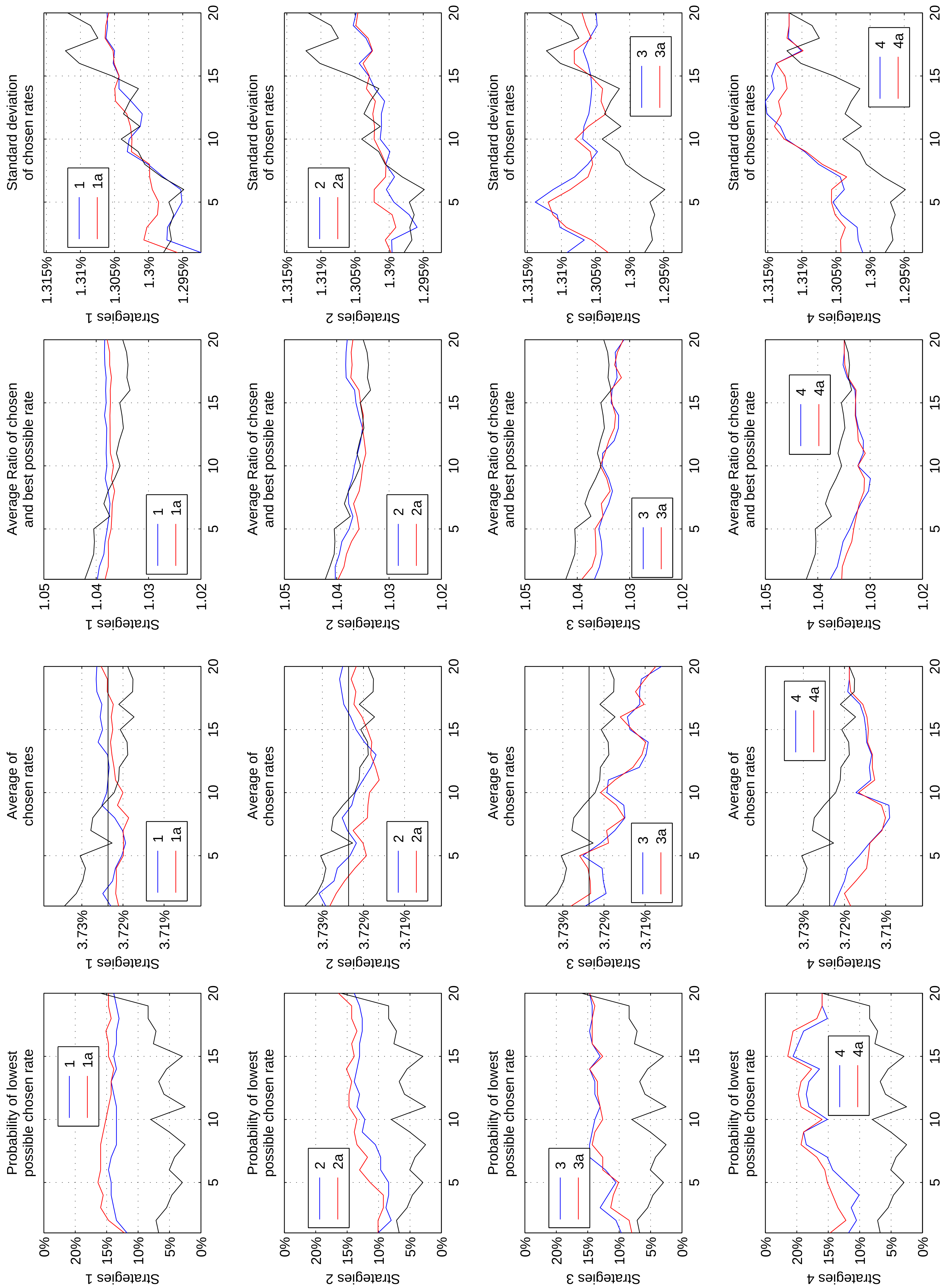


Figure A3. Simulation results for linear loans with 15 year maturity

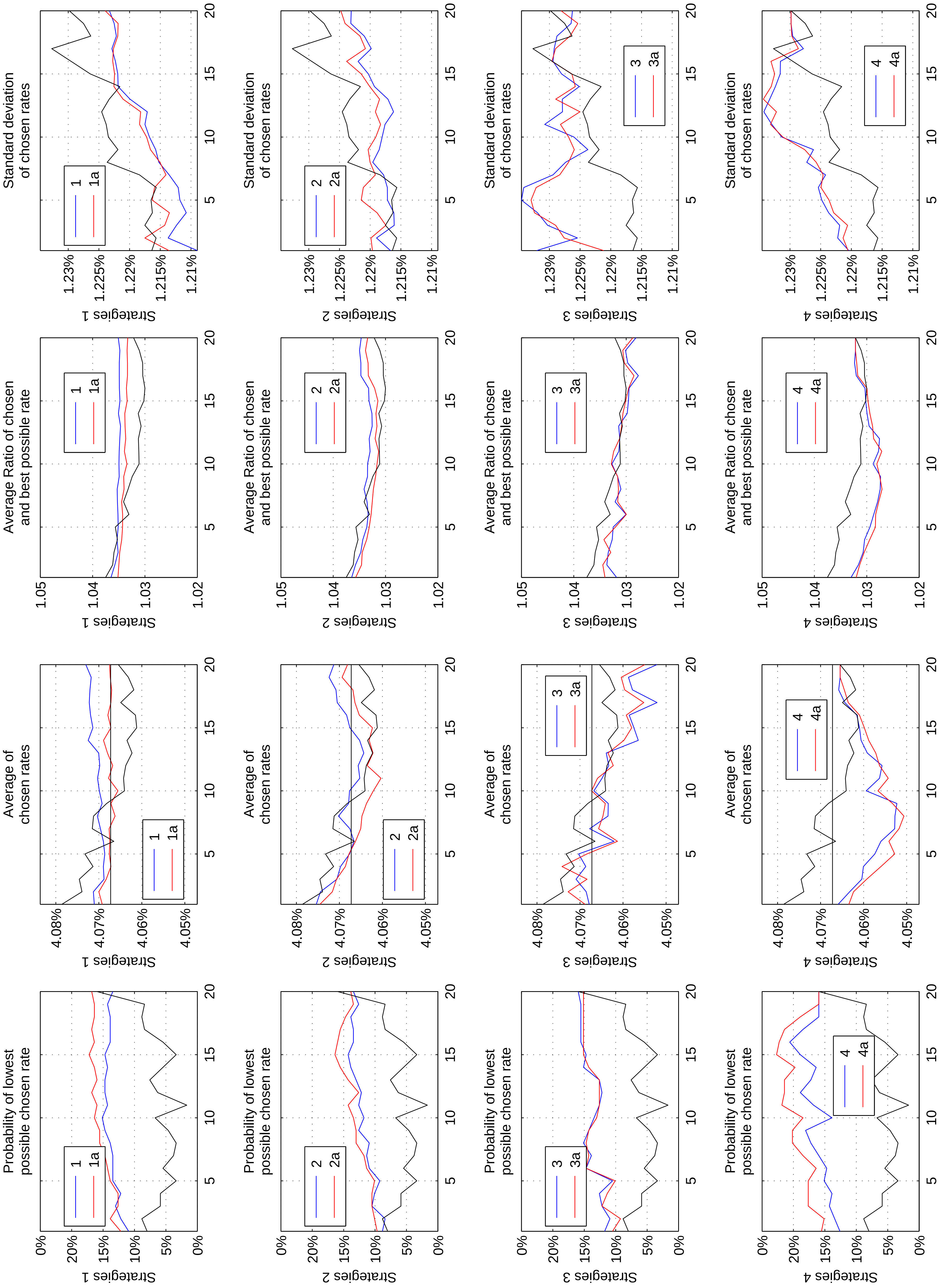


Figure A4. Simulation results for linear loans with 20 year maturity

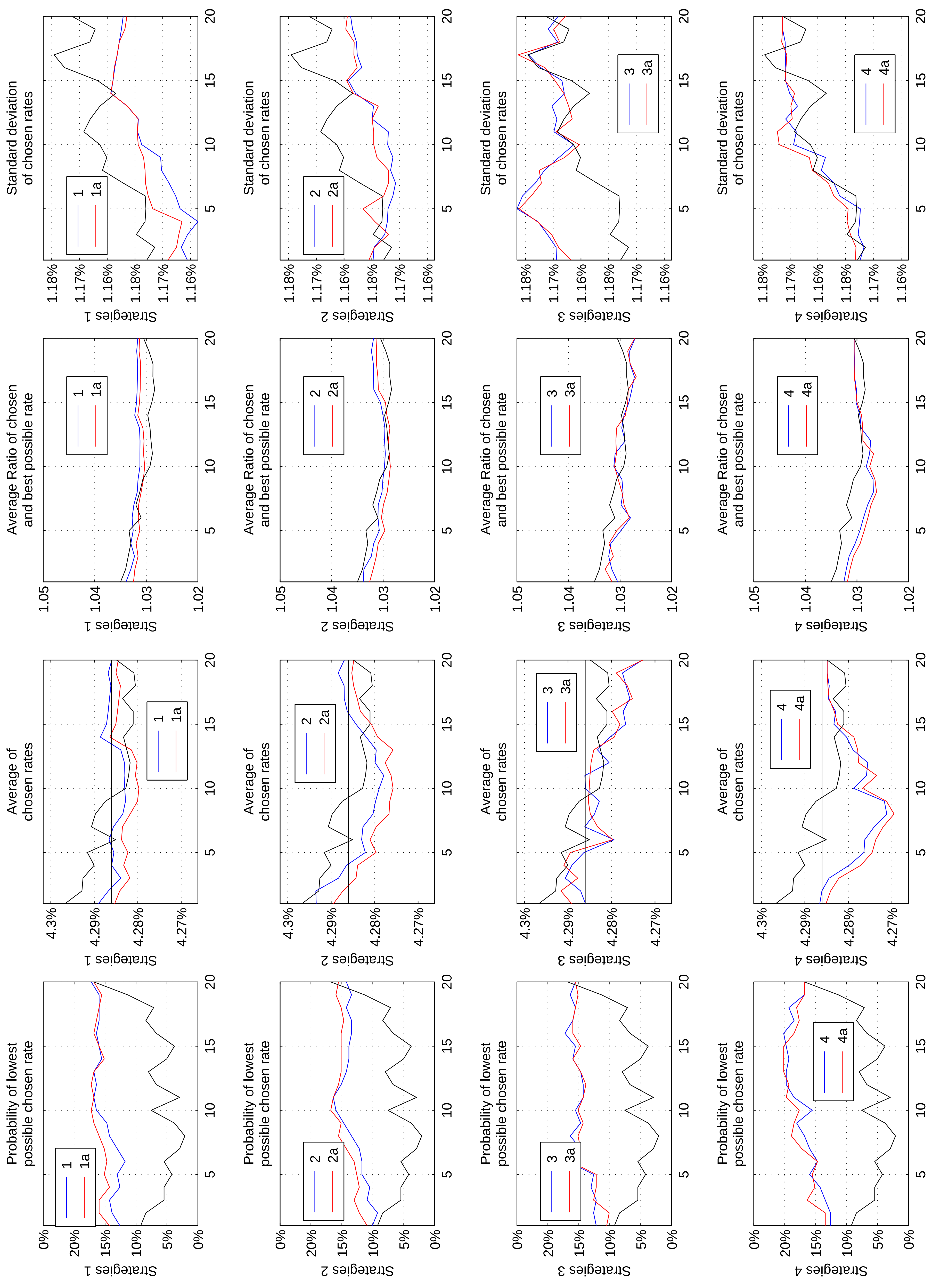
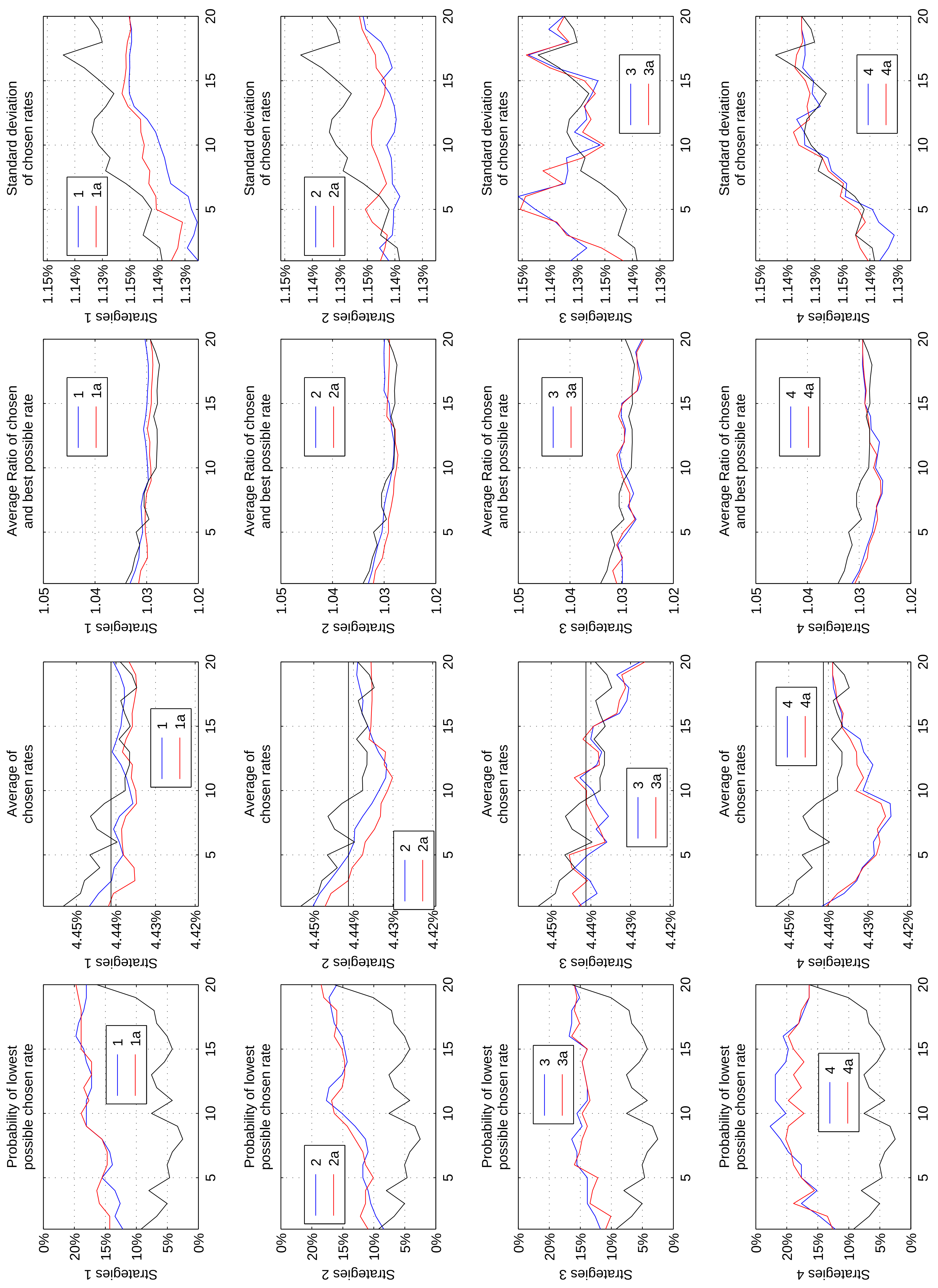


Figure A5. Simulation results for linear loans with 25 year maturity



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